HIGHWAY RESEARCH REPORT

BRIDGE DECK RIDEABILITY

FINAL REPORT

74-21

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

TRANSPORTATION LABORATORY

RESEARCH REPORT

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16. ABSTRACT

The objective of this project was to develop equipment to produce bridge surface profiles and make specification changes to control riding quality by use of these profiles.

A 12-foot profilograph, a laser beam true profiler, and the 25-foot California Profilograph were tested and compared on a number of bridge decks.

Use of the 12-foot profilograph was shown to be faster and more effective for evaluation of bridge deck smoothness than the 12-foot aluminum straightedge. Surface deviations were located with the profiling equipment that were not located or not capable of being located with the 12-foot aluminum straightedge.

A proposed specification and test method are included in this report.

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RONALD REAGAN, Governor

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June 1974

Translab No. 635287
Federal No. F-8-16

Mr. R. J. Datel
State Highway Engineer

Dear Sir:

Submitted herewith is a final research report titled:

BRIDGE DECK RIDEABILITY

By

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Very truly yours,

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ACKNOWLEDGMENTS

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INTRODUCTION

The riding quality encountered by a motorist should not change significantly whether he is on a bridge or on highway pavement. It is common, however, for some bridge decks to give an inferior ride as compared to most highway pavements. The initial highway pavement roughness appears to be adequately controlled while the rideability of some bridge decks leaves much to be desired.

The present method for controlling roughness of bridge deck surfaces is with the use of a 12-foot aluminum straightedge. The straightedge is placed on the deck, usually immediately after the concrete placement, and any area that deviates more than 1/8-inch from the straightedge is marked for later corrective measures. The straightedge is then advanced longitudinally along the deck one half its length, and the deck rechecked. This procedure is repeated at various locations across the width of the structure. This method for controlling roughness is considered inadequate because of the shortness of the straightedge and the nonuniformity of procedure and analysis. A considerable amount of inspection effort is required to locate surface irregularities exceeding the specified limits.

Prior to beginning this project, data was obtained from a study made by bridge engineers in one area comparing the 12-foot aluminum straightedge to the 25-foot California Profilograph which is used in controlling portland cement concrete pavement roughness. The findings indicated there are bumps that are visible on the profilograms and can be felt in a vehicle traveling at highway speeds (in other words, contribute to poor riding quality), but could not be located with the 12-foot aluminum straightedge or were within present specifications for the 12-foot straightedge.

The application of the California Profilograph for deck evaluation has been considered at various times, but there are certain problems that would first have to be resolved. These are:

1. The overall length of the profilograph is 32 feet. Thus, profiles of the entire deck cannot be obtained without being influenced by the adjoining pavement. The pavement is often not in place for several months after completion of the bridge which also complicates obtaining early profile data.

2. Nothing is known of the effect of dead load deflections on the profiles. Camber is usually built into bridge decks to offset dead load deflections and later creep. Just how much effect this factor might have on profilograms and their interpretion is undetermined.

3. The time lapse between construction of the deck, evaluation of smoothness, and conducting of grinding operations must be considered.

4. How should bridge approach slabs be considered? The over-all riding quality supplied to the motorist should be of concern whether it be pavement, approach slabs, or bridge deck.

Due to the large amount of manual labor required for deck inspection, some type of mechanical profiler appears to offer the greatest potential to control bridge deck rideability. Through a literature search, it was found that there are primarily two types of mechanical profilers.

1. A "true" profiler which produces a profile referenced to a fixed datum plane.

2. A "Relative" profiler which produces a profile referenced to a moving datum plane (1).*

The objective of this project was to develop equipment to realistically measure riding surface profiles of newly constructed bridge decks. From this, make necessary changes in specifications to control rideability of bridge decks and approaches.

The three profiling devices evaluated in this study are defined as follows:

1. California Profilograph - a 25' rolling straightedge with an articulated wheel system supporting each end, and a chart recorder driven by a profile wheel near the center of the unit.

2. Bridge Profilograph - a 12' rolling straightedge with a single wheel at each end and a chart recorder driven by the rear wheel of the unit. The profile wheel is located in the center of the unit. This instrument is a modified version of a commercially available device known as a "Hi-Lo Detector".

3. Laser Beam Profiler - a hand pushed profiling unit that incorporates commercially available components for laser-controlled leveling operations.

CONCLUSIONS

Deck surface profiles obtained by the 12-foot and 25-foot profilograph are more accurate, faster and easier to obtain, and lend themselves to rideability evaluation better than a straightedge

*Numbers in parentheses refer to references at end of report.

placed on the deck surface. A permanent record of the surface profile is a great aid in locating bumps or depressions.

Test profiles of numerous bridge decks with the 25-foot California Profilograph and the 12-foot Bridge Profilograph show surface deviations that were missed previously by use of the 12-foot aluminum straightedge.

The ease with which the Bridge Profilograph can be handled and the adequacy of the recorded profilogram make it the most desirable profiling device of those studied.

Evaluation of the profiles indicates that the relative profile produced with the California Profilograph (because of its greater length) does approach the "true" magnitude of the bump more closely than does the Bridge Profilograph for bumps with lengths of more than approximately 25 feet. The vertical deviations normally found by the 12-foot straightedge are of relatively short length, however, and for the purpose intended each of the two profile devices shows the magnitude of these deviations equally well.

All bumps that are detectable with the 12-foot aluminum straightedge are readily shown on the profilograms taken with the Bridge Profilograph. With proper use of deck profiles, bumps will not be missed or overlooked.

Profiles obtained with the Laser Beam Profiler did not adequately illustrate small amplitude bumps nor did they lend themselves readily to evaluation. The "true" profile thus obtained, accurately shows long amplitude undulations as well as grade changes. Riding quality is more affected by short bumps which are better illustrated and evaluated by use of a relative profiler.

The method developed for evaluation of profiles obtained with the Bridge Profilograph is similar to that used in California Test Method 526 for highway pavements. This method can be applied to deck profiles, and specification limits adjusted to acceptable values as necessary.

IMPLEMENTATION

The Bridge Profilograph will give relative profiles of deck surfaces which are sufficient for contract control of deck roughness.

There is no anticipated reduction in costs by implementation of the use of the 12-foot Bridge Profilograph. However more checks can be made with less effort which should result in smoother riding bridges and more uniform contract control procedures.

The methods for obtaining and evaluating profiles of bridge deck surfaces are given in detail in the appendix of this report. The basic limits are as follows:

> "Using the prescribed templates and procedure if any portion of the profile line extends above the 0.2-inch opening on the "must grind" template, or if a count exceeds 5 per 100 feet, then corrective measures are necessary."

Tests have shown that these limits will produce a riding surface equal to or better than one where roughness was controlled by use of the regular 12-foot straightedge.

Implementation should be started by using the proposed specification on a few selected contracts. This would provide both the State inspectors and the contractors a chance to adjust any operational problems that may occur.

PROCEDURE

Observations were made as to the timing and procedure of the contractor's operations to determine (1) the difficulties in administering straightedge specifications, and (2) the kind of profiling equipment that might be used that would not necessitate a change or interruption in work procedures. Seven deck placements were initially observed and four more at various times throughout the project. At each job, the resident engineers and inspectors were interviewed to determine what they thought might be an improvement over the existing straightedge method of controlling deck roughness. Suggestions were received and carefully evaluated. The general requirements most often mentioned were as follow:

1. Lightweight
2. Easily transported
3. Operated by one man
4. Usable for early detection. Preferably usable from the time the deck is "walkable" on green concrete to completion.

Though not often mentioned, the capability of producing a permanent record of the deck profile was also considered.

A literature search was made to determine if any equipment was available that might meet the above requirements. It was found that no one had developed a lightweight "true" profiler that was portable enough to use on newly constructed bridge decks. One company did produce laser beam components which could possibly be developed into a "true" profiler. It was decided to attempt to develop both a true profiler and a lightweight profilograph meeting the requirements previously listed.

A Hi-Lo Detector was purchased from Soil Test Incorporated (see Figure 1) and was modified for use with a continuous strip chart recorder from a California 25-foot Profilograph.

It was concluded after early trials that the California 25-foot Profilograph was too long and unwieldy for obtaining profiles of newly constructed bridge decks prior to placement of adjoining pavement (see Figure 2). However, because of its extensive use on pavements, the California Profilograph was used in conjunction with the modified Hi-Lo Detector as a comparison to the shorter 12-foot profilograph.

A true profiler was developed using a laser beam as a fixed reference datum with a receiving component which "locked" on the beam (see Figure 3). The receiver is mounted on a mast which is moved up or down hydraulically depending on the location of the laser beam datum.

Figure 1. A modified Hi-Lo Detector (Bridge Profilograph) with recorder. It is 12 feet long and separates into two pieces for easy transport.

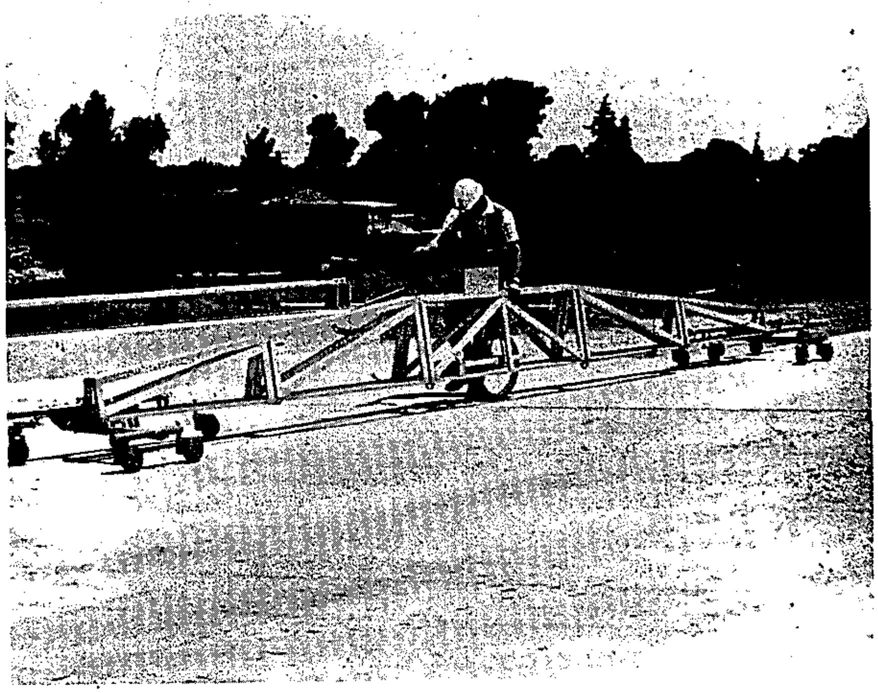

Figure 2. Standard California 25-foot Profilograph. Nominal 25' wheelbase. Frame breaks down into 5 pieces for transport.

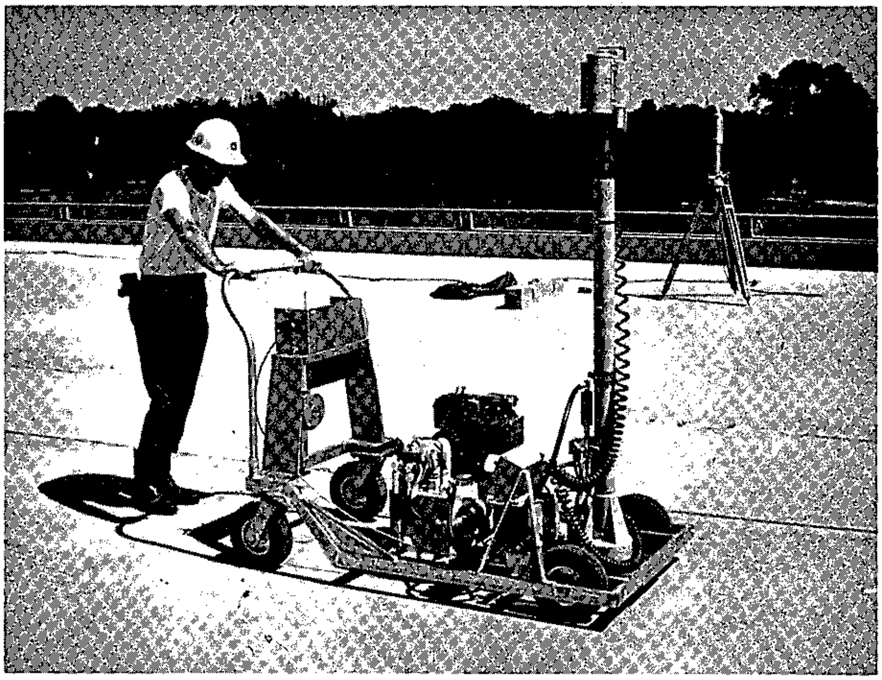

Figure 3. The laser beam profiler. The moveable "receiver" weighs 450 pounds. Tripod mounted laser beam source in background.

The entire unit, laser receiver, hydraulic pumps, gas engine power source, and recorder were mounted on a small 3-foot by 4-foot, 4-wheeled aluminum frame which had castered rear wheels and a push handle in the rear. The recorder was a strip chart recorder from a California Profilograph. The laser beam emitter was such that the beam was rotated horizontally at a rate of 5 revolutions per second to produce a plane of light. The laser components, both emitter and receiver units, were rented from the Laserplane Corporation of Dayton, Ohio. The components were originally designed for use in land leveling operations or other grade controlled devices such as ditch digging machines. The accuracy of the equipment is ± .01-foot in 1000 feet. With this equipment, a true profile can be obtained but, as discussed in more detail later, the profile produced does not show each individual bump with adequate resolution.

The three devices produce traces as shown in Appendix I, Figure 1. Each profilograph was developed to produce profiles with true vertical scale but with different horizontal scales. The profilogram obtained with the California Profilograph has a horizontal scale of 1-inch equals 25 feet, the Bridge Profilograph, a scale of 1-inch equals 15 feet, and the Laser profiler a scale of 1-inch equals 5 feet. Different horizontal scales were used as each type of equipment has its own mechanical and interpretative limitations. As shown in Appendix I, Figure 2, the Bridge Profilograph with a horizontal scale of 1 inch equals 15 feet tends to amplify the shorter bumps. At locations 1, 2, and 3 on these profiles, visual observation shows that profiles produced with the Bridge Profilograph separates into several bumps what appeared to be only one bump or several insignificant bumps on profiles produced with the California Profilograph at a scale of 1 inch equals 25 feet. This separation of the bumps on the profilograph allows for easier evaluation.

Other raw data obtained in addition to profiles consisted of type and dimensions of the structure, design cross slope and grades, and a comparison of bumps located by use of the profilographs with that located with the 12-foot straightedge presently in use.

The first bridge structures used for comparison of profiling equipment were completed structures with the adjoining concrete pavement in place. Some surface grinding had already taken place on the deck surfaces. When possible, profiles were run in each wheel track of each traffic lane with all three profile devices. As the laser beam cart wheels were 3 feet apart, the wheel track was kept in the center of the frame. Bridge deck profiles of many types of structures were obtained including box girder, T-beam, flat slab and steel girder.

After ten structures had been profiled and all data collected, final evaluations of the individual performance of each machine were made.

Examination of the profiles produced by the laser profiler shows that small individual bumps on the bridge deck surface were not visible on the profilogram. With a scale of true vertical and 1 inch equals 5 feet horizontal, it was determined that when the slope of the surface to be profiled varied more than 1 percent from that of the plane of light being projected, the profile line produced would be at a steep angle from horizontal on the profilogram. When the profile did attain this steep angle, such as on vertical curves, the individual bumps are completely obscured because of the small angle between the vertical direction from the surface being profiled and the slope of the line on the profilogram. The profile paper is only one foot wide, so when a large elevation change occurred, such as on vertical curves with a middle ordinate of more than 1 foot, a discontinuity was necessarily produced in the profilogram (see Figure 3). Where the surface to be profiled was straight grade but at an angle to the horizontal, the laser beam could be tilted to the same angle and a discontinuity in the profile for this situation would not be necessary.

An example of a problem encountered is shown in Figure 1 of Appendix I. From this profilogram, it can be seen that the profile line appears to "jump" in a series of steps of .01-foot elevation increments. This is the result of the combined effects of the width of slots in the receiver and the pulse type movements of the mast hydraulic system. While sensitive enough for the use intended for this equipment (grading control) it was not sensitive enough for deck profiling. The laser system may have been modified to improve the sensitivity but the cost, coupled with the other problems associated with use of this equipment, was not considered worthwhile.

The laser profiler could produce the general profile grade line of the bridge deck surface and some special tests were performed to test this ability. Profilograms in Figure 4 of Appendix I show the surface profiles of a bridge before and after striking falsework. The changes in camber and immediate settlements are measurable. A similar profile was obtained before and after prestressing operations with equally good results. The laser profiler system as used did not produce profiles which could be used for control of deck smoothness, therefore it was considered to be unsatisfactory for the purposes of this study.

Both the California Profilograph and the Bridge Profilograph are considered to provide good relative profiles of bridge deck surface irregularities. Each machine has its advantages and disadvantages, some of which have already been discussed. Comparison of the profiles on Figures 2 and 5 show that in most instances, the California Profilograph shows a more definitive picture of surface deviations than the Bridge Profilograph, especially if the bump has a length of around 30 feet. This may be of minor importance since it appears from observations that the deviations present on bridge deck surfaces are generally of a shorter length than those present on highway profiles. This is thought to be because of the type of equipment, methods and conditions generally encountered in bridge construction. With the shorter bumps each of the machines show the magnitude equally well and, in many cases, the Bridge Profilograph will, because of its shorter length and expanded horizontal scale, detail the bumps more clearly.

As stated before, both rolling straightedge type profilographs performed well on the completed decks with the adjoining pavement in place. The next step was to test these two machines under contract control conditions. Some bridge decks were profiled immediately after the curing compound was dry to a "no pick-up" condition. Others were profiled when two to three weeks old (see note). Because of its length, the California Profilograph could only profile to within 16 feet of the paving notch, while the Bridge Profilograph could profile to within 6 feet of the paving notch. The California Profilograph frame breaks down into five fairly large pieces and is difficult for one man to place them on the deck. The small Bridge Profilograph breaks down into a five- and seven-foot section, and can be taken across the abutment excavation with little difficulty. Because of its size and weight, the California Profilograph will scar the curing compound on green concrete, but the smaller profiler causes no problems in this regard.

Several decks were profiled to see if deck camber caused any effect on the profiles and how the profiling procedures would fit into the contractor's construction operation. It was found that camber was not distinguishable on profilograms obtained with these two devices. Problems encountered in using the 12-foot Bridge Profilograph as a construction control tool are:

1. <u>Profiling may be hampered by the contractor's operations</u>.

Profiling immediately after the deck finishing operation is possible provided the contractor promptly removes the finishing bridges and other equipment from the work area. Profiling during and after completion of the deck cure is hampered by curing rugs, exterior girder forms and other lumber, and screed rails, all of which may be scattered across the deck. It is often difficult to get the deck clean enough for profiles and also coordinate with the bridge railing construction.

2. <u>The profile is obscured by "hash" caused from residue left on the surface by the texturing procedure</u>.

This problem is one encountered at almost any time the deck is profiled. Excessively heavy transverse texture and other surface irregularities which cannot be readily removed by sweeping cause "hash" on the profile making it difficult to interpret. An example is shown in Figure 1 of Appendix I.

3. <u>Prior to placement of the adjoining pavement, profiles can be made only to within 6 feet of the paving notch</u>.

This means that the deck surface near the paving notches cannot be evaluated until the adjoining pavement is in place. A 12-foot straightedge, however, might be used for these short sections if necessary, to get the last 6 feet at each end of the bridge.

Note: The usual method for bridge deck cure in California is to use a white pigmented curing compound on the fresh concrete and four hours later place wet mats on the deck which are left in place for a total of 7 days.

To compare the 12-foot profilograph with the present system of using a 12-foot aluminum straightedge, eight bridge decks were studied. Each bridge deck had previously been tested by construction personnel and "all the areas tested were found to comply with the specified straightedge requirements". Profiles were obtained with the Bridge Profilograph and it was found that there was at least one bump on every bridge deck that did not comply with the specified straightedge requirement. On one structure, 177 feet long and 54 feet wide, three profile lines were obtained with the Bridge Profilograph (see Figure 6, Appendix I) and a total of eight bumps not complying with the straightedge requirements were located. The Bridge Profilograph thus appears to be a much better tool for evaluating bridge deck surfaces than the 12-foot aluminum straightedge.

The final step in this project was the development of a method of evaluation of the profilograms obtained with the 12-foot Bridge Profilograph.

Many evaluation techniques were considered and applied. Most methods were variations of that used in the California Test Method No. 526, "Operation of California Profilograph and Evaluation of Profiles". One method involved the use of a blanking band placed on the profilogram such that any portion of the profile that was visible above or below the band would be outside specification limits. Another method investigated the use of a "bump template" only, and still others tried were combinations of bump templates and blanking bands of various sizes and allowable limits.

No one method was shown to have any particular advantage over another and it appears that each method tried could be adjusted to determine areas needing correction. On that basis, it was decided that there would be an advantage to using an evaluation system similar to that already in use for California PCC pavements.

A proposed new specification and test method are given in the Appendix I of this report. The test method requires the use of a bump template and a blanking band with a scale. The limits in the proposed specification and template sizes in the proposed test method are different from those used for pavement. Portland cement concrete pavement specified limits are in terms of the allowable number of deviations per 0.1 mile of pavement and single bumps over 0.3 inches in height. Since many bridge decks are shorter in length than 0.1 mile, a limit was established in terms of allowable number of deviations per 100 feet of deck surface. To compensate for the difference in height of bumps caused by the different wheel bases of the profilographs (as discussed earlier in this report), the single bump limitation was established at a maximum of 0.2 inches in height. The design of the template was based on comparative tests made using the California Profilograph profilograms and California Test Method No. 526. This comparison was made to insure that the new method would not require unreasonable corrective measures on the deck surface.

Implementation of this method of controlling deck smoothness was performed on a connector overcrossing at an interchange with Interstate Route 280. Prior to corrective grinding, the entire deck was profiled in each wheel track of the No. 1 lane using a California Profilograph, a 12-foot Bridge Profilograph, and a PCA Road Meter* car (4) with profile capabilities. Corrective grinding was performed on the south half of the structure as determined by the Bridge Profilograph proposed test method and the other half of the structure was corrected using the standard 12-foot straightedge method with job personnel. Numerous bumps were missed using the straightedge. At the completion of corrective grinding, the entire deck was reprofiled using the California Profilograph and the Bridge Profilograph. Additional grinding was necessary on the south test portion to reduce the profile count to 5 per hundred feet according to the proposed test method. Final profiles were obtained with the Bridge Profilograph and Road Meter car, another device used by the Transportation Laboratory on pavement research work.

The profiles obtained show the south half of the bridge deck to be considerably smoother than the north half (see Appendix I, Figures 7 and 8). The Road Meter car results were inconclusive, but indicate that a greater improvement in riding quality was accomplished by grinding on the south half of the deck than on the north half (profiles are shown in Appendix I, Figures 9 and 10).

The use of bridge deck profiles for contract control of smoothness is a new approach. While the concepts presented in this report are not new, their application for controlling bridge deck roughness has not previously been used, at least to our knowledge. The methods and equipment outlined herein are not meant to be the ultimate answer, but are a foundation on which to build. As described under the section on implementation, the proposed specification should be used on a trial basis to iron out specific difficulties that might arise.

---

*The Road Meter consists of an electromechanical device installed in a conventional passenger auto, and provides a digital readout of the number and magnitude of the vertical deviations from a horizontal reference plane.

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APPENDIX I

Figures 1-10

CORRECTIVE GRINDING USING PROPOSED SPEC. AND THE BRIDGE PROFILOGRAPH

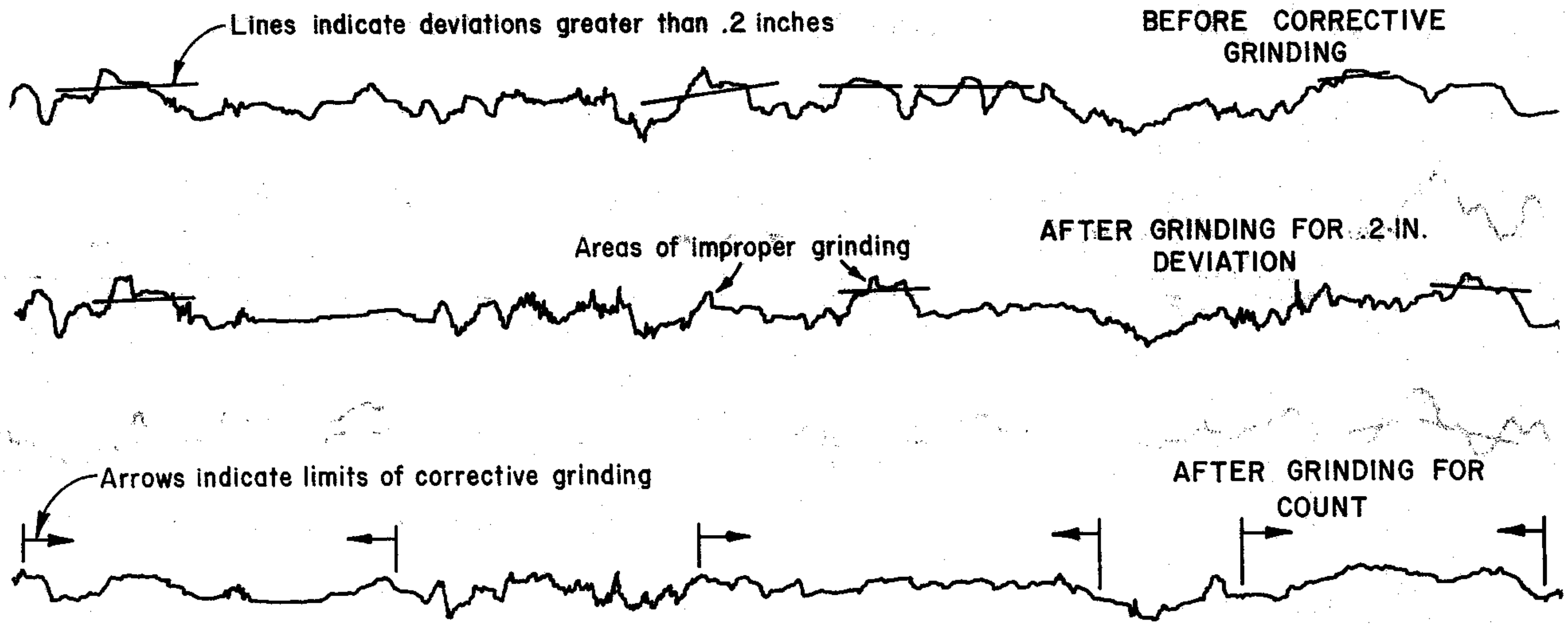
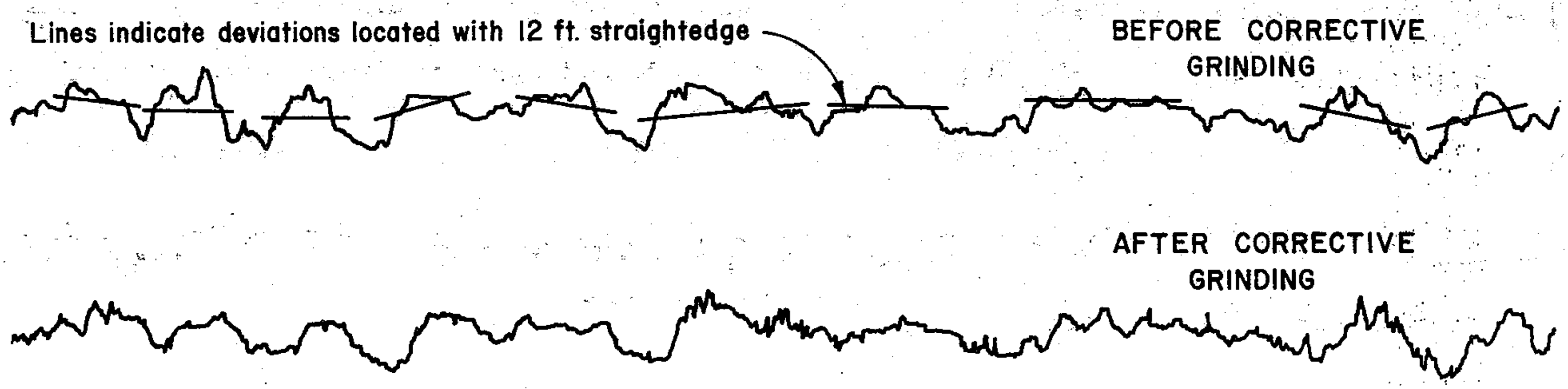


Figure 7

CORRECTIVE GRINDING USING 12 FT. STRAIGHTEDGE



Note: All profiles are taken with Bridge Profilograph
A number of bumps were improperly ground or not ground at all.

Figure 8

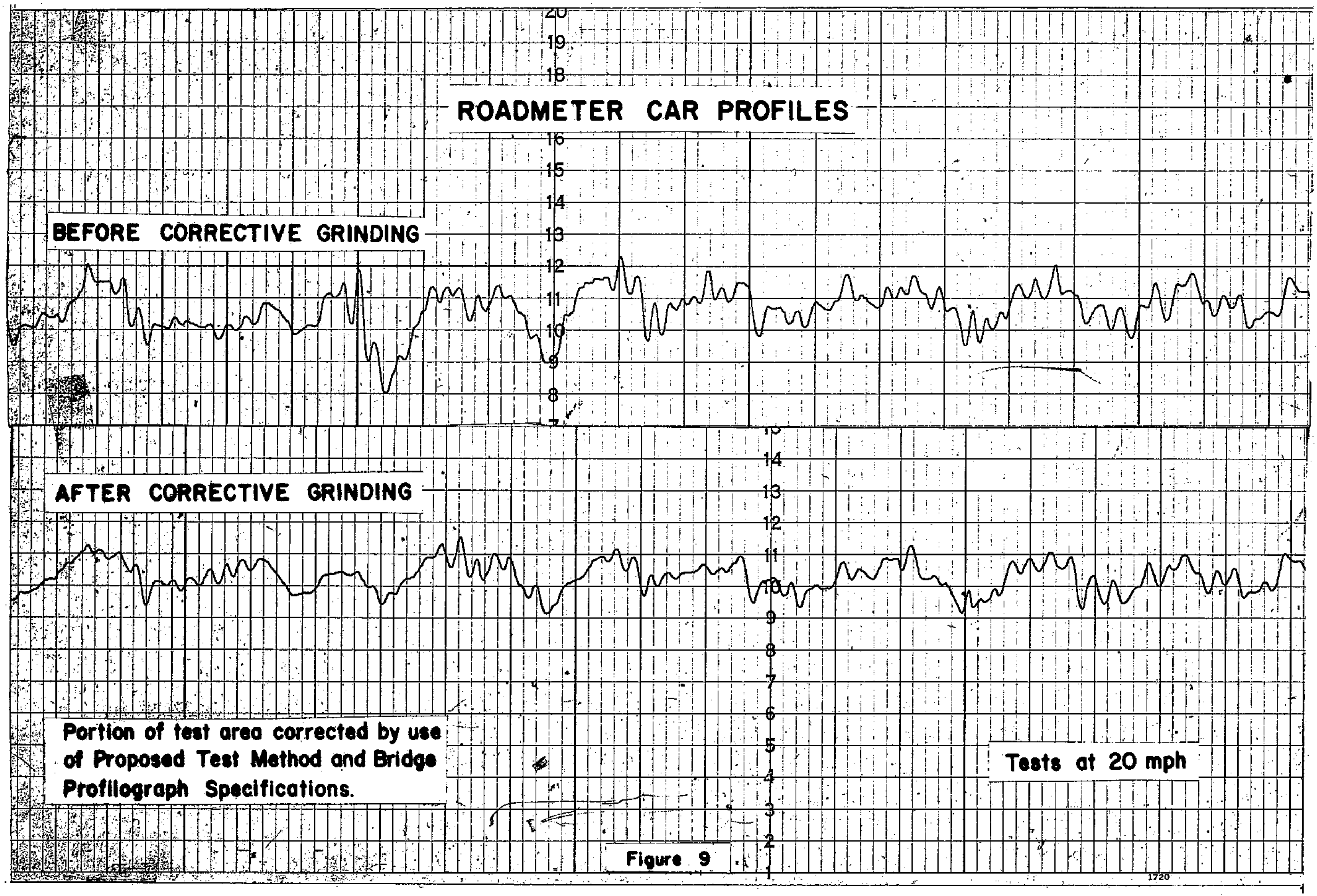

ROADMETER CAR PROFILES
BEFORE CORRECTIVE GRINDING
AFTER CORRECTIVE GRINDING
Portion of test area corrected by use of Proposed Test Method and Bridge Profilograph Specifications.
Tests at 20 mph
1720

Figure 9

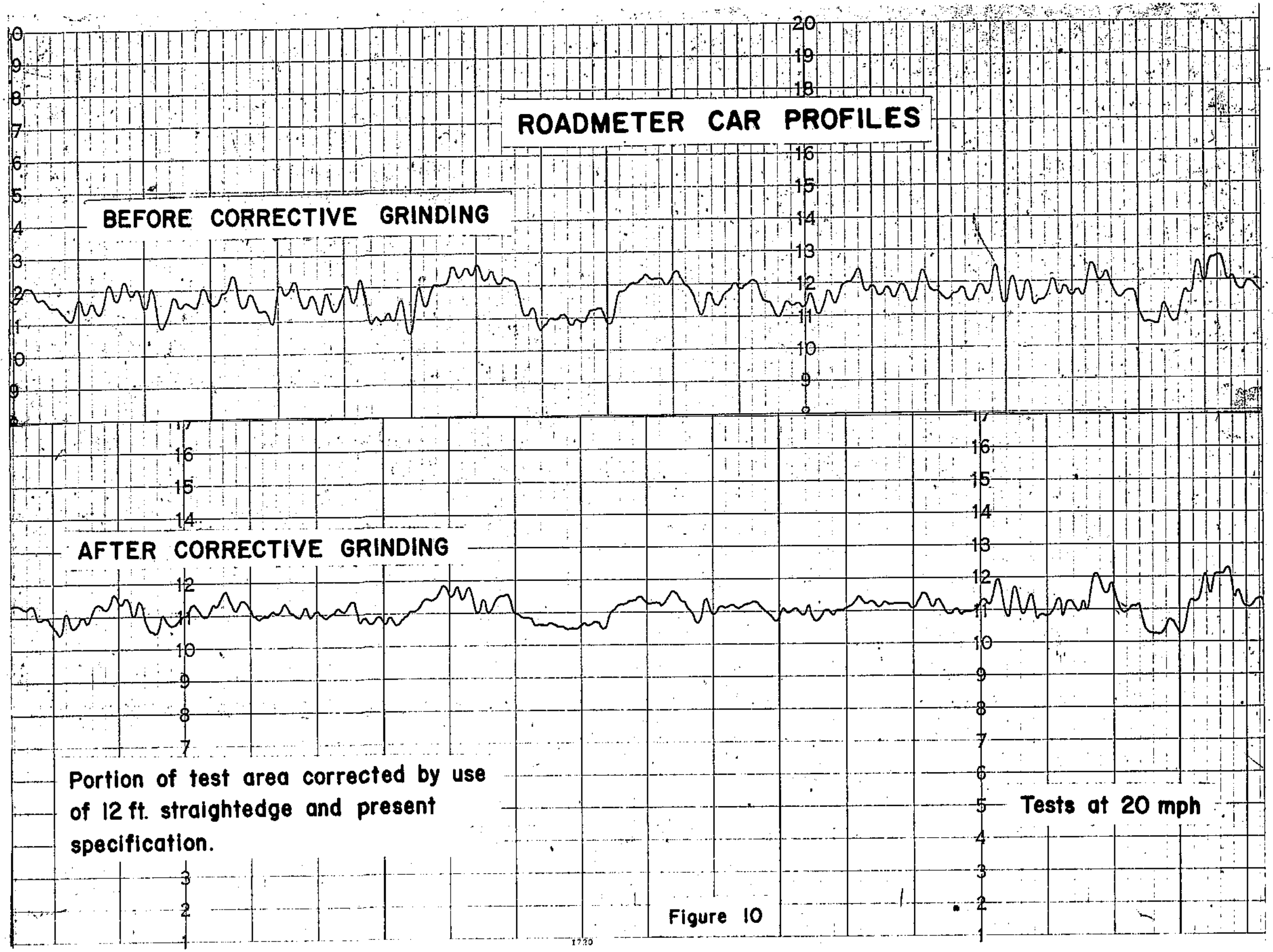

ROADMETER CAR PROFILES
BEFORE CORRECTIVE GRINDING
AFTER CORRECTIVE GRINDING
Portion of test area corrected by use of 12 ft. straightedge and present specification.
Tests at 20 mph

Figure 10

PROPOSED BRIDGE DECK SPECIFICATIONS

Immediately following the completion of the deck finishing operations, the concrete in the deck shall be cured as specified in Section 90-7, "Curing Concrete", of the Standard Specifications.

Within 3 days after the finishing operations the finished surface of the concrete bridge deck and approaches shall be profiled according to Test Method No. Calif. ____. Upon request from the Engineer, the contractor shall expose the bridge deck surface for the purpose of profiling. The surface shall be exposed only for that time necessary to obtain surface profiles.

The finished surface of the concrete deck and approaches shall have a profile count of 5 (0.5 inch) per 100 feet or less in any selected 100 foot section as determined by Test Method No. Calif. ___. ~~For the purpose of determining the performance of methods and equipment used by the contractor, Bridge deck~~ Initial profiles shall be obtained at approximately each planned wheel path of each traffic lane. ~~as shown on the contract plans~~.

(*) Put in Test Method

In addition to the requirement for profile counts of 5 per 100 feet or less, all areas representing high points having deviations in excess of 0.2 inch as measured by Test Method No. Calif. ___ shall be reduced by abrasive means until such deviations, as indicated by reruns of the Bridge Profilograph, do not exceed 0.2 inch.

After grinding has been completed to reduce all individual deviations in excess of 0.2 inch as provided in the above paragraph, additional grinding shall be performed if necessary to reduce the profile count to 5 counts per 100 feet or less, in any 100-foot section. Grinding shall extend the width and length of bumps within the traveled way. Ground areas shall be of uniform texture and shall present neat and approximately rectangular patterns.

Where the concrete of the bridge deck is to be covered by bituminous surfacing, earth or other cover, one inch or more in thickness, the surface of the concrete shall not vary more than 0.03 foot from the lower edge of the 12-foot straightedge.

When a straightedge 12 feet long is laid on the completed deck, the surface shall not vary more than 0.01 foot from the lower edge of the straightedge. Any points that are in excess of the tolerances set forth above shall be removed by abrasive means as provided in Section 42, Grinding and Grooving, of the Standard Specifications.

APPENDIX III

Test Method No. Calif. ___

OPERATION OF BRIDGE PROFILOGRAPH AND EVALUATION OF PROFILES

SCOPE

The operation of the Bridge Profilograph, the procedure for determining the "counts per 100 feet" from the profilograms, and the procedure for locating individual high points in excess of that specified, ~~0.2 inch~~, are described in Parts I, II and III respectively of this test method.

Part I - Operation of the Bridge Profilograph

A. Equipment

The Bridge Profilograph consists of a frame 12 feet long supported on one wheel at each end with an outrigger wheel for balancing support (see Figure 1). The profile is recorded from the vertical movement of a wheel attached at the midpoint of the frame and is in reference to the mean elevation of the end wheels in contact with the deck surface. The profilogram is recorded on a scale of one inch equal to 15 feet longitudinally, and one inch equal to one inch vertically. Motive power is supplied manually from the push handle in the rear. Steering is accomplished by rotating the handle grip to move the front wheel.

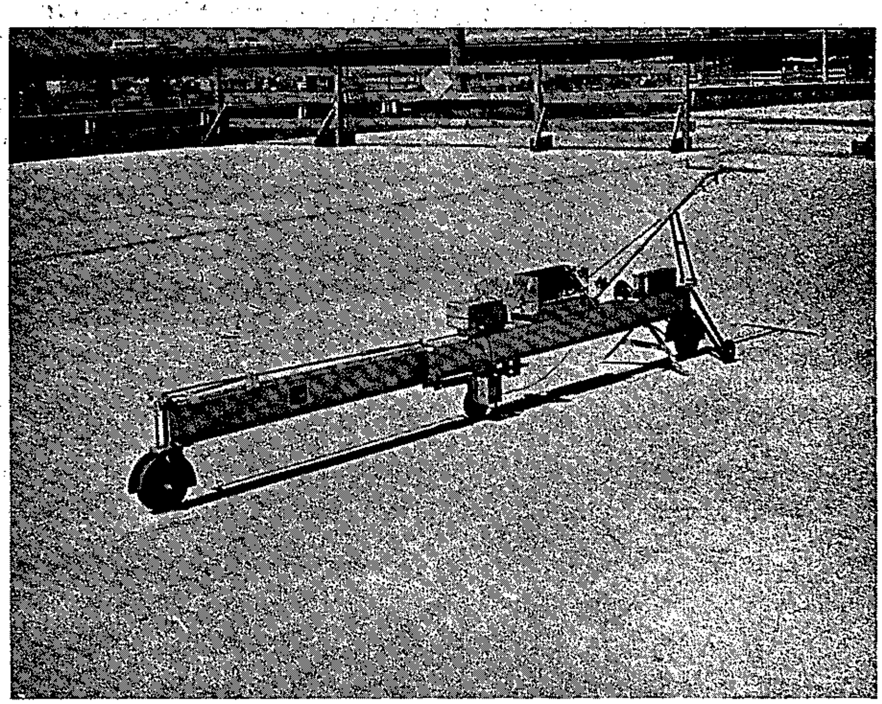


Figure 1. Bridge Profilograph

B. Operation

The Bridge Profilograph is transported in two pieces which readily bolt together. The steering linkage is connected with a pin and cotter key. The recorder is mounted by use of two spring clips on each end. A cable is connected from the profile wheel to the recorder for the vertical scale movement and a speedometer cable hookup to the rear wheel is used for the horizontal scale movement.

In operation, the profilograph should be moved at a speed no greater than a walk. Too high a speed will result in a profilogram that is difficult to evaluate. *

Calibration of the profilograph should be checked periodically. The horizontal scale can be checked by running a known distance and scaling the result on the profilogram. If the scale is in error of more than $\pm$ 2 percent, the rear wheel of the profilograph should be replaced with one of proper diameter. The vertical scale is checked by putting a board of known thickness under the profile wheel and again scaling the result on the profilogram. If the scale is in error, the cause of the incorrect height should be determined and corrected. The deck surface should be swept clean of any loose material along the paths to be profiled, and the wheels should be kept clean and free of particles which may become imbedded in the tires.

Part II - Determinations of Counts per 100 Feet from Profilograms

A. Procedure

To determine the "counts per 100 feet", use a plastic scale 1.70 inches wide and 6.66 inches long to represent a bridge deck length of 100 feet at a scale of 1" = 15'. Such a plastic scale may be obtained from the Transportation Laboratory, Sacramento. Near the center of the scale is an opaque blanking band 0.15-inch wide extending the entire length of 6.66 inches. On either side of this band are scribed lines 0.1 inch apart, parallel to the opaque band. These lines serve as a convenient scale to measure deviations of the profile line above or below the blanking band. These deviations are called "scallops".

B. Method of Counting

Place the plastic scale over the profile in such a way as to "blank out" as much of the profile as possible. When this is done, any scallops that appear above and below the blanking band will be approximately balanced (see Figure 2).

Starting at the right end of the scale, measure and total the height of all the scallops appearing both above and below the blanking band, measuring each scallop to the nearest 0.05 inch (half a tenth). Write this total on the profile sheet near the left end of the scale together with a small mark to align the scale when moving to the next section. Short portions of the profile line may be visible outside the blanking band but unless they project 0.03 inch or more and extend longitudinally for 0.15 inch on the profilogram or more, they are not included in the count. (See Figure 2 for illustration of these special conditions.)

When scallops occurring in the first 100 feet are totaled, slide the scale to the left, aligning the right end of the scale with the small mark previously made, and proceed with the counting in the same manner. The last section counted may or may not be an even 100 feet. If not, its length should be scaled to determine its length and then that portion of 100 feet should be prorated to equivalent 100 feet. For example:

Section Length	Counts, Tenths of an Inch per 100 Ft.
100 feet	4.0
100 feet	3.0
100 feet	2.0
60 feet (2.0 counts in 60 ft. prorated to 100)	~~3.5~~ 3.33

C. Limitations of Count in 100-foot Sections

When the specifications limit the amount of roughness in "any 100-foot section", the scale is moved along the profile and counts made at various locations to find those sections, if any, that do not conform to specifications. The limits are then noted on the profile and can be later located on the deck surface prior to grinding.

D. Limits of Counts

For the purpose of determining the profile counts, the profiles should be obtained within the limits of the concrete placement. Profiles of the first and last 6 feet of the section being tested cannot be obtained until the adjoining pavement or bridge section is in place. At such time that the concrete bridge approach pavement is to be evaluated, profiles should be obtained starting at least 60 feet prior to each ~~structure~~ approach slab continuously to at least 25 feet onto the bridge deck.

Part III - Determination of High Points in Excess of 0.2 Inch (or as other specified)

Procedure

A. Equipment

Use a plastic template having a line 1.33 inches long scribed on one face with a small hole or scribed mark at either end, and a slot 0.2 inch (or as otherwise specified) from and parallel to the scribed line (Figure 3). (The 1.33-inch line corresponds to a horizontal distance of 20 feet on the horizontal scale of the profilogram.) The plastic templates may be obtained from the Transportation Laboratory Branch, Sacramento.

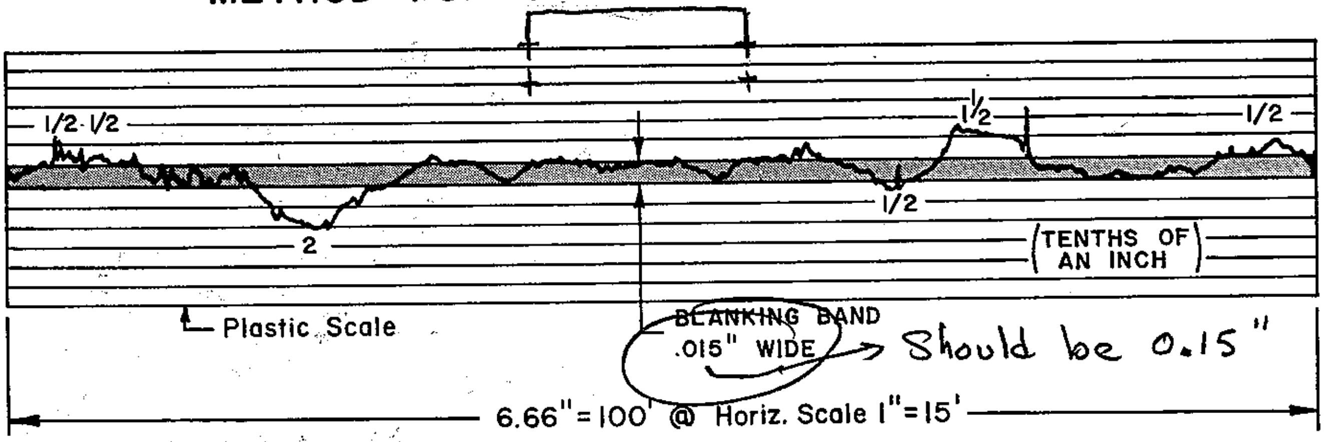
B. Locating High Points in Excess of 0.2 Inch (or as otherwise specified)

~~At~~ each prominent peak or high point on the profile trace, place the appropriate template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak or indicated bump. The line on the template need not be horizontal. With a sharp pencil, draw a line using the narrow slot in the template as a guide. Any portion of the trace extending above this line will indicate the approximate length and height of the deviation in excess of ~~0.2 inch.~~ the specified distance.

There may be instances where the distance between easily recognizable low points is less than 20 feet. In such cases, a shorter chord length shall be used in making the scribed line on the template tangent to the trace at the low points. It is the intent, however, of this requirement that the baseline for measuring the height of bumps will be as nearly 20 feet as possible, but in no case to exceed this value. When the distance between prominent low points is greater than 20 feet, make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. A few examples of the procedure are shown in Figure 3.

1.33

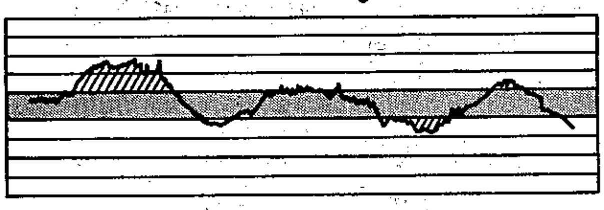
METHOD FOR OBTAINING PROFILE COUNTS



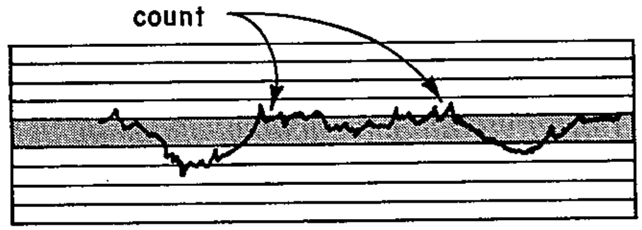
Total count for 100' section is $5\frac{1}{2}$

TYPICAL CONDITIONS

Scallops are areas enclosed by profile line and blanking band

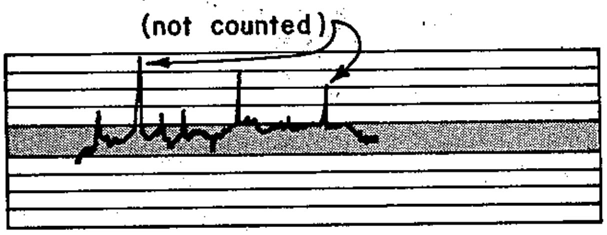


Small projections which are not included in the count



SPECIAL CONDITIONS

Rock or dirt on deck (not counted)



Double peaked scallop (only highest part counted)

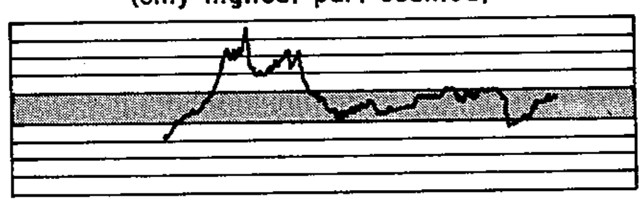
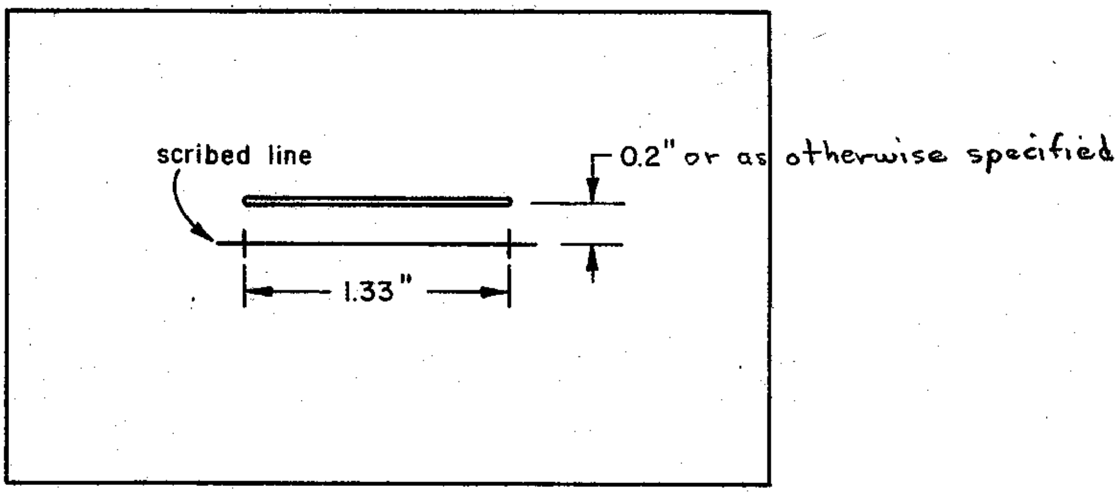
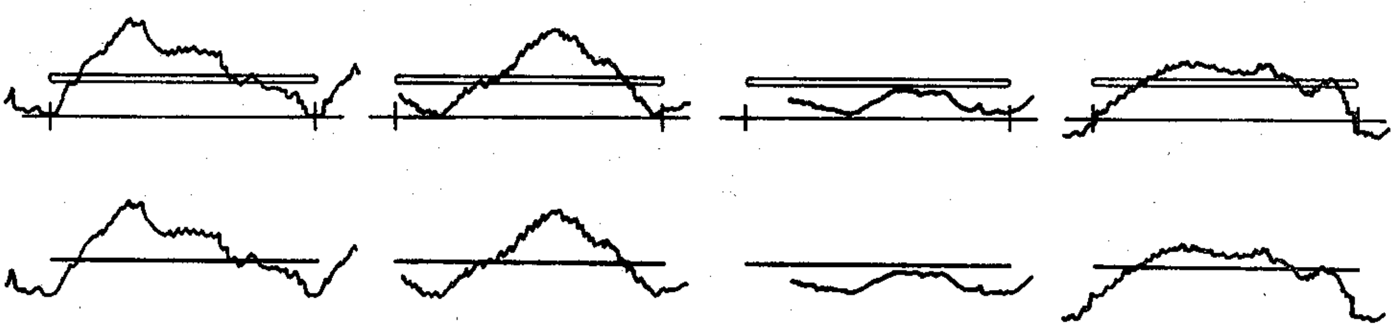


Figure 2

METHOD FOR PLACING TEMPLATE WHEN LOCATING BUMPS TO BE REDUCED



PLASTIC BUMP TEMPLATE



Baseline approx. 20 feet

Baseline less than 20 feet

Peak less than .02-in. high

Baseline more than 20 feet

CT Translab 7/74 3C

Figure 3